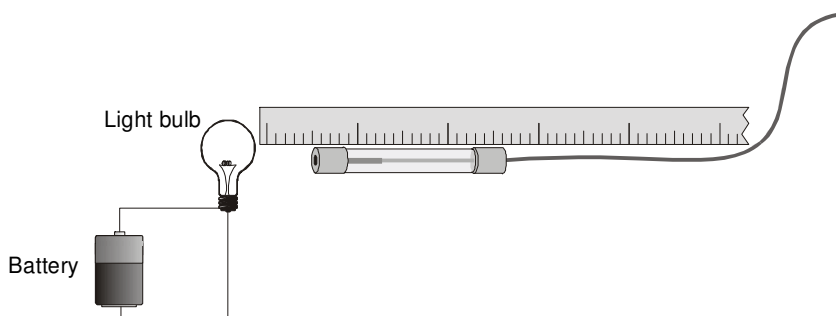


# Light, Brightness and Distance

You probably have noticed that a light appears to be brighter when you are close to it, and dimmer when you are farther away. If you are reading this page illuminated by a single light bulb, the amount of the light that strikes this page will increase as the page is brought closer to the light source. Using a Light Sensor, you can determine how the brightness of light varies with distance from the source and compare that result to a mathematical model.

There are several ways to measure the brightness of light. Since this experiment can be performed with any of several different light sensors, each of which measure slightly different quantities, we will just use the word *intensity* to describe the relative brightness of the light, although the term may not be strictly appropriate for your sensor. Regardless of the way light is measured, the same relative changes with distance are observed, and that is what you will study today. In this experiment you will measure light intensity at a variety of distances from a small source of light, and see how the intensity varies with distance.



*Figure 1*

## OBJECTIVE

- Determine the mathematical relationship between intensity and the distance from the light source.

## MATERIALS

Power Macintosh or Windows PC  
LabPro or Universal Lab Interface  
Logger Pro  
Light Sensor

meter stick  
clear glass light bulb (1.5 V penlight type)  
battery (1.5 V)  
Graphical Analysis or graph paper

## PRELIMINARY QUESTIONS

- Suppose a small light source is placed at the center of two transparent spheres. One sphere has a radius  $R$ , and the other a radius  $2R$ . An intensity  $I$  passes through the surface of the inner sphere. If no light is absorbed, so that all of the light emitted by the source passes through the inner sphere and reaches the outer sphere, what is the intensity at the outer sphere? Solve this problem by considering the following:

- How does the intensity passing through the inner sphere compare to the intensity reaching the outer sphere?
- How do the surface areas of the two spheres compare?
- In general, then, how will the intensity vary with distance from the source?

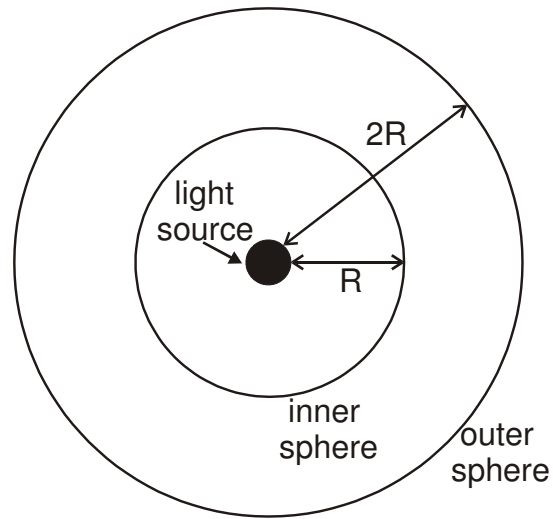


Figure 2




- Since most light bulbs that you use are not true point sources of light, how do you think the answer to Question 1 would change if a typical light bulb were used?

## INITIAL SETUP

- Connect the Light Sensor to Channel 1 of the LabPro or Universal Lab Interface. If your sensor has a range switch, set it to the 600-lux range.
- Make sure that the filament axis of the light bulb is horizontal and pointing directly at the Light Sensor. This makes the light bulb look more like a point source of light as seen by the Light Sensor.
- The filament and Light Sensor should be at the same vertical height (Figure 1).
- Place the end of the filament (not the glass) at the 0.0-cm mark of the meter stick.
- Open the Experiment 32 folder from *Physics with Computers*. Then open the experiment file that matches the type of light sensor you are using. A graph will appear on the screen. The vertical axis of the graph has intensity in units for your sensor. The horizontal axis has distance scaled from 0 to 12 cm. The Meter window will display light intensity.
- Turn down the lights to darken the room. A dark room is critical to obtaining good results. There must be no reflective surfaces behind or beside the bulb.

## PROCEDURE





- Place the Light Sensor 2 cm from the light bulb filament and note the value of intensity in the Meter window. Make sure that the intensity changes as you move the sensor, otherwise you may need to switch to a less sensitive scale or use a less intense light source. Move the sensor away from the bulb and watch the displayed intensity values. What is your prediction for the relationship between intensity and the distance to a light source?

2. Click  to begin data collection. Place the Light Sensor 2 cm from the light bulb filament. **Important:** The distance must be measured carefully. Be sure you measure from the filament of the lamp to the sensor on the Light Sensor.
3. Wait for the intensity value displayed on the screen to stabilize. Click , then type the distance between the Light Sensor and the light source and press ENTER to record the value of intensity. A point will be plotted on the graph.
4. Move the Light Sensor 1 cm farther away from the light source and repeat Step 3.
5. Repeat Step 3 moving the sensor in 1-cm increments until the Light Sensor is 10 cm from the light source.
6. Click  when you have finished collecting data. In your data table, record the intensity and distance data pairs displayed in the Table window (or, if directed by your instructor, print a copy of the Table window).

## DATA TABLE

Distance (cm)	Intensity

## ANALYSIS

1. Examine the graph of intensity *vs.* distance. Based on this graph, decide what kind of mathematical relationship you think exists between these two variables.
  - If the relationship is direct, then  $I = k \cdot d$  where  $k$  is a proportionality constant.
  - If the relationship is inverse, then  $I = k \cdot 1/d$ .
  - If the relationship is inverse square, then  $I = k \cdot 1/d^2$ .
2. To see if you made the right choice:
  - a. Click the Curve Fit button, . Select a fit type from the list of curve fits displayed, then click .
  - b. A best-fit curve will be displayed on the graph. If you made the correct choice, the curve should closely match the data. If the curve does not match well, try a different fit and click  again. When you are satisfied with the fit, click .
3. Does the function that fits the data best agree with your model of intensity using the concentric spheres?

4. List some reasons why your experimental setup might not match the relationship you predicted in the Preliminary Questions between intensity and distance.

## **EXTENSIONS**

1. Confirm the relationship between intensity and distance by finding the linear plot of  $I = k \cdot 1/d^2$ . You can use Vernier Graphical Analysis to verify the inverse square relationship between intensity and distance. Enter the data, then create a modified column of data with the heading "Distance<sup>-2</sup>" to represent  $1/d^2$ . Graph intensity vs. distance<sup>-2</sup>. A straight line that passes through the origin would verify the inverse square relationship.
2. If you have a window facing the sun, it may be interesting to try an experiment to measure the intensity of the sun. If your sensor has a range switch set it to the 150,000-lux range and load the calibration for that setting. Place the Light Sensor 10 cm from a 150 W clear light bulb and measure the intensity. Point the Light Sensor at the sun and measure the intensity of the sun relative to the light bulb. How many light bulbs would you have to place 10 cm from the Light Sensor to be equal to the intensity of the sun? Use the mathematical relationship found in this lab to calculate the intensity of the sun if it was placed 10 cm from the Light Sensor. Determine how many of these light bulbs would be equivalent to this value.
3. Use the Light Sensor to measure the intensity of the sun over the period of an entire school day.
4. Use the Light Sensor to examine sunglasses. By what percentage is the sun's intensity reduced when sunlight passes through the lens of sunglasses?
5. Use the sensor to compare other light sources to the light source that you used in the lab. For instance, how does intensity vary as you move away from a long fluorescent bulb or a circular fluorescent bulb?